BRIEFER ARTICLES.

THE PROBABLE FUNCTION OF CALCIUM OXALATE CRYSTALS IN PLANTS.

A RATHER comprehensive study of vegetable histology (medicinal plants), extending over a period of six years, has brought to my attention more specifically the great abundance and wide distribution of crystals of calcium oxalate, and has led to the formulation of a theory as to their probable function in the plant economy.

There seems to be no logically deducible reason for assuming that the crystals serve as a protection against herbivorous animals, though such a theory was promulgated by Stahl and others and is now widely accepted by teachers of botany.

Calcium oxalate occurs in four predominating form types. Of these the least common is the crystal sand (Krystallsand, Krystallmehl, Krystallpulver) which occurs in the roots of belladonna, in the stem parenchyma of *Solanum dulcamara*, species of Atropa, Datura, Physalis; bark of Sambucus, Cinchona, and in some other plants. The prismatic and aggregate forms are perhaps about equally common and are very widely distributed. The needle-shaped or acicular crystals are also very common, but predominate in monocotyledonous plants.

Leaving out of consideration the still undecided question of the chemical formation of the crystals in the plant and the causes which lead to the production of one or the other form type, we shall refer briefly to their probable function.

G. Kraus in 1891 expressed it as his opinion that calcium oxalate was a reserve product to be redissolved by the plant and again utilized. This applies, however, only to a part of the crystals deposited during the previous season. Calcium oxalate dissolves with difficulty. It is insoluble in water, alcohol, ether, acetic acid, saliva, and other animal secretions. Being insoluble in these substances it is also tasteless; hence taste cannot enter as a factor to guard against destruction by herbivorous animals. Nor is this substance poisonous. Some of it would no doubt be decomposed by the secretions of the digestive tract (as free hydrochloric acid in the stomach), but not enough to produce poisoning due to

the oxalic acid liberated. It is generally admitted that the oxalic acid in various plants, as Rheum, Rumex, etc., serves as a protection against animals, not because of its highly poisonous nature, but because of the extremely sour and astringent taste.

The theory that calcium oxalate serves to keep away animals through mechanical interference is highly improbable for several reasons. If this were the case the crystals would be peripherally located, as in this position they would soonest produce the desired effect. The crystals actually occur about uniformly distributed through the tissues of the various plant organs, and are in many instances especially abundant in the interior, as in the spongy tissue of leaves, the pith of stems, and the heart wood of stems. This mechanical interference can have application to small animals only, such as snails, insect larvae, etc. The crystals could not possibly injure or repel large animals capable of destroying the entire plant rapidly.

Based upon observation, the conclusion is reached that the prime function of calcium oxalate in plants is that of mechanical support; secondarily it plays the part of a reserve product as stated by Kraus. The following are the chief reasons in favor of the mechanical support theory:

1. Cells containing prismatic crystals are quite generally associated with bast fibers. These crystal-bearing fibers consist of rows of rectangular, thin-walled cells, each cell bearing, as a rule, a single crystal. The cells surround the bast fibers or bast bundles. They are very abundant and distinct in the bark of Salix, Quercus, and Populus, for example. They enclose completely the single enormous bast cells of quebracho, and occur in the majority of bast-bearing barks and stems, and are associated with the bast tissue of vascular bundles. Bast cells are essentially non-elastic; the crystal-bearing cells and fibers enclosing the bast give elasticity. This is shown to a remarkable degree in the inner bark of Quillaja, which contains an enormous quantity of large, elongated prismatic crystals of calcium oxalate distributed through the bark parenchyma.

2. In other instances the crystal-bearing cells are not merely an aid to mechanical tissues, but serve as a substitute therefor, functionally taking the place of sclerenchyma. For example, in the seed of quince there is found a sclerenchymatous tissue below the layer of mucilaginous epidermal cells. In the white garden bean this sclerenchymatous tissue is replaced by a layer of cells carrying large prismatic

crystals so constructed and placed as best to resist vertical and diagonal pressure, as of soil particles and the weight of the bean.

In the case of acicular crystals, so prevalent in monocotyls, it is evident that they give elasticity as well as support against crushing pressure. This applies especially to the very long and comparatively thick needles of calcium oxalate found in squill, iris, and other members of the lily family. These crystals (raphides) are especially common in the parenchyma of roots, rhizomes, tuberous roots, stems, and leaves.

It is generally admitted that the cystoliths of Ficus leaves, etc., perform a purely mechanical function. In plant organs subjected principally to a radial pressure, as are thick roots, tubers, thick rhizomes, etc., not specially supplied with mechanical elements, the aggregate crystals predominate, *e. g.*, Rheum and Rumex. In such organs as potatoes, corms of Colchicum, etc., the necessary mechanical support is given by the starch which fills the cells. A potato free from starch would be crushed by the soil in which it grows.

Further evidence in favor of the mechanical support theory of calcium oxalate is to be deduced from the fact that in many instances the crystals are imbedded in a gelatinous or mucilaginous substance which equalizes the pressure exerted, acting as a bumper between cell-wall and crystal. In other instances the cell-sap takes the place of the mucilage.

It is very frequently found that cells bearing calcium oxalate take the place of mechanical cells in leaves. The crystals are especially common in the cells bounding the air chamber of stomata which certainly require some mechanical support.

It is also highly probable that calcium oxalate is merely accidentally present in some plants and plant organs, but in the majority of instances its presence points toward a function of mechanical support as indicated.— ALBERT SCHNEIDER, *Northwestern University School of Pharmacy, Chicago.*